U. S. DEPARTMENT OF AGRICULTURE.

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THE COTTON BOLLWORM:

SOME OBSERVATIONS AND RESULTS OF FIELD EXPERIMENTS IN 1904.

By

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., January 14, 1905.

SIR: I have the honor to transmit herewith the manuscript of an account of The Cotton Bollworm, based upon investigations conducted during the year 1904, prepared by A. L. Quaintance and F. C. Bishopp of this Bureau, and to recommend the immediate publication of the same as a Farmers' Bulletin. The investigations are in continuation of those reported for the year 1903 and published as Farmers' Bulletin No. 191, which this bulletin is designed to supersede.

Very respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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INTRODUCTION.

The cotton bollworm became known as an enemy of cotton early in the history of the cultivation of this crop in the United States. As the industry has grown, the losses from this insect have assumed greater proportions, especially in the absence of the employment of any remedial measures, and more particularly in the Southwestern States of the cotton belt, where farming conditions and practices have been least calculated to interfere with its successful development.

From long familiarity, planters have become more or less accustomed to its ravages, and the disposition has been to regard these as necessarily incident to cotton culture. The fact that serious injury has been of irregular occurrence has contributed to the disposition to neglect the adoption of remedial measures long known to be of value. Probably the most difficult feature of the whole question of lessening the present serious ravages of the bollworm consists in securing the adoption by cotton growers of methods generally admitted to be of value. This difficulty is not peculiar to cotton farmers suffering from bollworm ravages, but finds parallel among the growers of agricultural and horticultural crops generally. Often a pest of long standing will be tolerated, and no effort made to prevent injury from it, whereas the ravages of a recently introduced species become the subject of much complaint; of which facts the cotton boll weevil and the cotton bollworm furnish an excellent illustration. Curiously enough, the crisis in cotton culture in Texas, brought about by the former species, will, it appears, be the means of securing the adoption, in that State at least, of methods of farming best calculated to reduce injury from the cotton bollworm. Certain facts in the life history of the latter species render effective those cultural methods which are of value in avoiding weevil injury. It now appears certain that both of these serious enemies of the cotton plant will be best controlled by identically the same methods of improved farm practice.

[a] *Heliothis obsoleta* Fab., formerly known as *H. armiger* Hübner.

SUMMARY OF LIFE HISTORY AND HABITS.

The bollworm has four distinct stages in its development—namely, the egg, larva, pupa, and adult or moth.

The eggs are most easily found on the silks of corn, and may be readily seen with the unaided eye. They are oval in shape, whitish or yellowish in color, and average in diameter about 0.45 to 0.50 mm. The number of eggs deposited by a single moth varies from about 500 to 3,000 with an average of about 1,100. The eggs are laid, beginning usually about twilight, on the several food plants of the larvæ, which are preferably corn, cotton, tomatoes, etc., in about the order named. Eggs on corn are placed almost promiscuously over the plant, but there is shown a preference for silks when these are present. On cotton, eggs are placed more largely on the leaves and squares, but there is a considerable scattering of them over the entire plant. Eggs hatch in from two and one-half to ten days, depending on the season.

In the larval stage, the insect is variously designated as bollworm, bud-worm, corn ear-worm, tomato-fruit worm, etc., depending on the particular plant and part of the plant infested. It is during this stage only that injury is inflicted. Newly hatched bollworms are very small, and are usually overlooked by planters until they are of sufficient size to attract attention by their injury. The bollworm is a voracious feeder, and during the summer may complete its growth in from twelve to fifteen days. During the cool weather of spring and fall the rate of growth is much slower. A full-grown bollworm measures from 1¼ to 1½ inches in length. Larvæ vary much in color and markings, ranging, in different individuals, from pale greenish to rose-colored, dark brown, and almost black.

When full grown the bollworm leaves its food plant and burrows in the soil to a depth, usually, of from 2 to 5 inches, and, after constructing a cell extending upward nearly to the surface of the soil, enters the pupal stage. This stage, during summer, lasts from ten days to two weeks, and longer in the spring and fall. The insect hibernates in the pupal condition.

The bollworm moth, like its larva, varies much in color, ranging from a dull olive green to a pale yellow. The wings expand about 1½ inches, and the body is about ¾ of an inch in length. During the day the moths hide in grass or weeds around the margins of fields or among the foliage of plants infested by the larvæ. Toward dusk they leave their retreats and feed on the nectar of various flowers. In cotton fields their principal food is the nectar secreted on the squares and flowers of the cotton plants. After feeding oviposition begins, or this process may alternate with feeding. Eggs are deposited almost

promiscuously over the plants. This habit of promiscuous oviposition, especially on the cotton plant, renders it possible, during periods of severe bollworm injury, to employ arsenical poisons for the destruction of young larvæ before they are of sufficient size to attack squares and bolls.

The number of generations annually produced by the bollworm in the cotton belt varies from about 4 to 7, depending on the latitude, with an average of about 5. In the latitude of Paris, Tex., there appear to be but 4; at Victoria, Tex., there are apparently 6. The irregularity in time of appearance of moths in the spring and other causes soon produce a confusion of generations, so that these are rarely well marked.

In general, moths issue from hibernating pupæ in the spring, in any locality in the cotton belt, at a time when most of the field corn is from 10 to 20 inches high. By far the larger part of the eggs of these moths is placed on young field corn. A small part is placed on other plants, as garden vegetables, roses, etc. The larvæ resulting from eggs laid on field corn attack the tender central roll of leaves, soon riddling it, and are on this account termed bud-worms. In the latitude of Paris, Tex., moths of the second generation appear as field corn is coming into tassel and silk. These portions of the plant are freely oviposited on, and the second generation of bollworms largely infests the same parts, especially of roasting ears, in which infestation may reach as high as 90 to 100 per cent of the ears. By the time the moths of the next generation are out, field corn has begun to yellow and ripen and is no longer attractive to the moths for oviposition purposes; hence these go to cotton, from which they secure nectar as food and on which most of their eggs are deposited. Cotton is not attacked in force by bollworms until the corn of the locality has begun to ripen, which time will average about the first of August. The third generation of bollworms is the one most destructive to cotton. The fourth generation, also, infests cotton during September, but owing to the attack of parasites, and frequently to unfavorable weather conditions, injury is rarely of serious proportions.

Larvæ of this generation, on completing their growth, enter the soil and transform to pupæ, in which condition the majority remain during the winter. A few may develop moths, and there are thus some bollworms to be found on cotton quite up to frost.

FARM PRACTICE IN RELATION TO BOLLWORM INJURY.

At the present time in the United States injury to cotton from the bollworm assumes its greatest importance in Texas, Louisiana, Mississippi, Indian Territory, Oklahoma, and Arkansas. The rapid increase in cotton acreage during the past ten or twenty years in the

more western part of the cotton belt has contributed largely to the more serious depredations of the bollworm in this territory, as compared with its injuries in the Carolinas, Georgia, and Florida. Those who have followed the development of cotton culture west of the Mississippi during recent years need not be informed how extensive this development has been. Quoting from the Twelfth Census:

> Of the entire crop 34.5 per cent was grown west of the Mississippi River in 1879; 38.44 per cent in 1889, and 43.89 per cent in 1899. Of the total increase of 4,099,831 acres in the decade, 1890 to 1900, 3,637,398 acres or 88.7 per cent was contributed by Texas, Indian Territory, and Oklahoma. The increase in Texas was 3,025,824 acres; in Indian Territory, 371,987 acres; in Oklahoma 239,569 acres. This leaves an increase of onl 462,433 acres for all the other States, which was nearly reached by the increase of 440,970 acres in Alabama.

The tide of emigration, which about 1850 began to move westward from the more eastern cotton States, peopled this newer country largely with cotton farmers, and cotton has been the crop raised, largely to the exclusion of everything else. Until recently but little attention has been given to diversified farming, corn and cotton being the principal crops grown. As transportation facilities have improved the tendency has been, perhaps, to depend more and more on the North and West for the food supply and to increase the farm acreage in cotton. This extension of the cotton area and neglect of crop diversification has resulted partly from the belief that climate and soil were not adapted to the cultivation of those crops grown successfully farther north, but more largely on account of labor and economic considerations. Landowners have for the most part come to consider cotton as the only crop which may be grown on a large scale with reasonable convenience and safety to themselves, and there has thus been developed a condition of finances which has necessitated the planting of cotton by tenants and small landowners in need of credit, as collateral for the amounts advanced.

Plantations and farms of large size are the rule, and the tenant system, therefore, finds its maximum development in the area under consideration. This fact, in connection with the large areas in cotton, as compared with other crops, and the natural fertility of the soil, which produces a rank succulent plant growth, have been important factors in bringing about the present importance of bollworm ravages.

The cotton crop requires the occupancy of the ground from early in the spring until late in the fall, the growth of the plant being checked only by frost. If the fall be unfavorable, picking may be greatly delayed, often extending through the winter and well into the following spring. Under such circumstances a thorough plowing of the ground in the fall or winter, with its consequent beneficial influence in destroying hibernating pupæ, is not possible, and land

may be planted to cotton several years in succession without a thorough breaking up. By reason of the tenant system of farming, cultivation has, on the whole, been insufficient, and the plant has thus been least able to put on an excess of early fruit, so as to insure a crop in spite of insect attack.

The situation is aggravated by the use of seed which has not been selected for early fruiting or other desirable qualities, often from public ginneries and of absolutely unknown variety.

The principal crops grown, namely cotton and corn, are the two preferred food plants of the bollworm. As a general rule the agricultural practices of the States and Territories mentioned result in conditions theoretically most favorable for the development of this insect. The serious ravages of the bollworm which this territory, and to a less extent other portions of the cotton belt, have suffered, have their explanation in prevalent methods of farm practice. The movement for diversification of crops, now well under way in Texas, and other improvements in farming must gradually bring about that condition of relative immunity from injury enjoyed by the older, more eastern cotton-belt States.

DESTRUCTIVENESS OF THE BOLLWORM.

Bollworm injury varies much from year to year, depending on the relative earliness of the cotton crop, the character of the weather, and

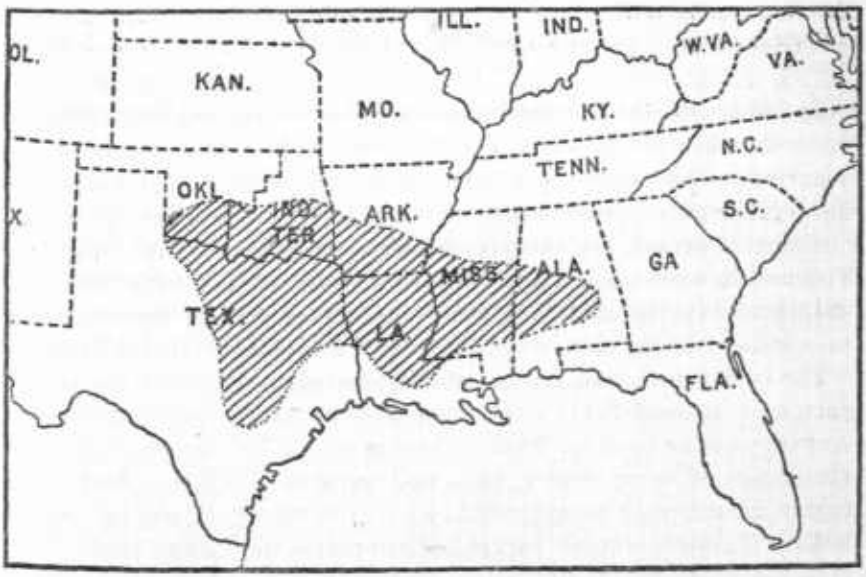

FIG. 1.—Map showing approximately the area of bollworm injury in 1904.

other factors. Not for many years have its depredations been more widespread and serious than during 1903. The heavy and general

rains during the winter of 1902–1903 practically prohibited winter plowing, and from the same cause planting in the spring was everywhere delayed from four to six weeks. Subsequent weather conditions, especially in late July and early August, were such as are held to be most favorable to bollworm development. The general lateness of the cotton crop resulted in there being but little fruit sufficiently matured to be exempt from attack upon the migration of the insects to cotton in early August. The capabilities of the insect for injury under such conditions are very great. In the territory infested by the boll weevil the combined attack of these two species often left but little to be gathered. A yield of 1 bale on from 15 to 25 acres was frequently reported, and in some fields no cotton whatever was gathered.

The following estimates of bollworm injury in 1903 in certain counties in Texas are made up from data from various sources and from personal observation, and are given to indicate the capabilities for injury of this species under such conditions as prevailed during that year:

Estimates of bollworm injury to the cotton crop in certain counties in Texas in 1903.

	Per cent.		Per cent.
Navarro	20 to 25	Lamar	40 to 50
Henderson	15 to 20	Delta	50 to 60
Limestone	20 to 25	Hunt	30 to 35
Falls	8 to 10	Hopkins	25 to 30
Bell	8 to 10	Kaufman	25 to 30
Robertson	15 to 20	Van Zandt	20 to 25
Fannin	50 to 60		

In pleasing contrast were the much less serious ravages of the insect in 1904, when it was only more or less locally that severe injury occurred. The favorable weather of the fall of 1903 and the following winter and spring permitted very general breaking up of land during this period, and many pupæ were undoubtedly thus destroyed. The moths were noticeably much less numerous in young field corn during the spring, and they were subsequently much less abundant, as evidenced by the number of eggs on the silks of early and late corn.

The cotton crop was, on the whole, planted at or before the normal date, and in most fields a fair crop of bolls had so matured by early August as to be exempt from bollworm attack in the presence of an abundance of more tender bolls and squares. While complaint of injury came from a considerable range of territory, it was not, on the whole, of serious extent, except on late cotton on bottom lands.

In the accompanying map (fig. 1) the shaded area marks approximately the territory infested in 1904. The average annual injury to the cotton crop of the South, mostly confined to the western part of the cotton belt, is probably not less than $11,500,000.

PLAN AND SCOPE OF INVESTIGATION.

The present bollworm investigation has been conducted largely in Texas, in view of the seriousness of the depredations of the pest in that State. The work was begun in the spring of 1903 and has continued to the end of the year 1904. The investigation has been prosecuted both in the laboratory and in the field. During 1903 headquarters were established at Victoria, Tex., where office and other facilities were available in the building occupied by the force engaged in cotton boll weevil investigations. Experiment farms were established at Calvert, Wills Point, and Hetty, Tex., covering in all 140 acres. Only one entomologist was engaged in the work. The more important results of the work of 1903 have been given in Farmers' Bulletin No. 191 of this Department. In 1904, by reason of an increased appropriation, the work was considerably enlarged. Headquarters were established at Paris, Tex., where a laboratory was equipped for the study of all points likely to throw light on methods of control. Four entomologists were continuously engaged in the investigation, and a fifth during the summer and fall months.

In the field, experiments were conducted largely along the lines followed in 1903, as follows: (1) To determine the possibility of making a crop of cotton before the period of greatest bollworm injury, by the early planting of early-maturing varieties of cotton, aided by fertilizers and by thorough cultivation; (2) to determine the value in bollworm control of spraying or dusting cotton with arsenical poisons; (3) to determine the value of corn as a trap crop in protecting cotton from bollworm injury.

In the prosecution of this work it has been necessary for the Department to have control of numerous tracts of land, along with labor and farm equipment. These have been secured by means of contracts with planters whereby the planter has been guaranteed a satisfactory yield of cotton in return for the obligation assumed to carry out the Department's instructions as to the growing and handling of the crop. In the course of the investigation, experiment and demonstration farms have been established as follows:

Experiment farms used in work with the bollworm, 1904.

Location.	Plantation of—	Number of acres.
Paris, Tex	L. J. Bankhead	40
Ladonia, Tex	C. T. Jackson	100
Hetty, Tex	Capt. B. D. Wilson	30
Sulphur Springs, Tex	Hon. J. T. Hargrove	50
Pittsburg, Tex	J. F. Harrison	40
Wills Point, Tex	Capt. A. N. Alford	50
Do	O. L. Johnson	40
Shreveport, La	Hon. W. L. Foster	40
Mound, La	Capt. F. L. Maxwell	55
Quinlan, Tex	Joe Smith	30
Terrell, Tex	Demonstration farm of E. H. R. Green.	15

In addition to the 490 acres represented above, numerous smaller areas have been utilized in cooperation with planters, increasing the aggregate to about 600 acres.

On these farms tests have been made of every expedient likely to be of value in circumventing bollworm injury. The scheme as to cultural methods has included the comparison of early-maturing varieties of cotton from the more northern States with local varieties, and of early with late planting; a study of the effect of fertilizers in increasing the crop and in hastening maturity; and a comparison of average cultivation with thorough cultivation under all of the above conditions. Such work, as will at once appear, bears directly on the bollworm question in its relation to the production of an early crop.

The accompanying diagram of a 48-acre field will serve to illustrate the method followed in the solution of the several questions involved. The methods of treatment enumerated have thus been brought into comparison under the uniform conditions as to soil, etc., which are necessary in experimental work of this kind.

Experimental cotton plats of the Department of Agriculture at Ladonia, Tex., 1904.

Plat 1. Early planted. Early variety. Thorough cultivation. Fertilized.	Plat 2. Early planted. Early variety. Thorough cultivation. No fertilizer.	Plat 3. Early planted. Native seed. Thorough cultivation. No fertilizer.
Plat 4. Early planted. Early variety. Average cultivation. Fertilized.	Plat 5. Early planted. Early variety. Average cultivation. No fertilizer.	Plat 6. Early planted. Native seed. Average cultivation. No fertilizer.
Plat 7. Late planted. Early variety. Thorough cultivation. Fertilized.	Plat 8. Late planted. Early variety. Thorough cultivation. No fertilizer.	Plat 9. Late planted. Native seed. Thorough cultivation. No fertilizer.
Plat 10. Late planted. Early variety. Average cultivation. Fertilized.	Plat 11. Late planted. Early variety. Average cultivation. No fertilizer.	Plat 12. Late planted. Native seed. Average cultivation. No fertilizer.

Experiments designed more particularly to test the effect of several classes of fertilizers were conducted on the principal types of soil of north Texas, and the plan and results of this work on two of the typ-

ical soils are detailed on a later page. Owing to complications which would result from the presence of the weevil, these experimental farms were as much as possible located in sections comparatively free from this pest in Texas.

One feature of the work has been the comparison of varieties of cotton with especial reference to their earliness, prolificness, and quality of staple. In all, 75 supposed varieties of cotton have been compared during the past year.

In the case of insects attacking staple crops, the margin of profit in their cultivation does not often permit of the employment of remedial measures other than those involving changes or improvements in farm practice. However, the readiness with which cotton may be poisoned with Paris green or other arsenicals, particularly in a dry form, by means of poison blowers or the primitive but effective method of bags suspended from poles, has placed this operation among those which may reasonably be employed. Considerable attention has been given to the matter of testing poisons in bollworm control, both in 1903 and 1904. In all cases the plan has been to measure off, say, 20 acres of uniform cotton, 10 of which would be poisoned and 10 left as a check. The efficacy of the treatment has been measured by the yield from the respective areas.

No rational plan may be formulated for the control of an insect except as based on a thorough knowledge of its life and habits. The importance of life-history studies is therefore evident. The laboratory investigations of the past two years have covered all important features of the biology of the bollworm, confirming many points already known and enlarging our knowledge of the species. The determination of the number of generations was effected by the use of a large breeding cage in which corn and cotton were grown exactly as in the fields. These observations were checked by rearing experiments in the laboratory. The destructive capacity of individual bollworms was determined repeatedly by confining a larva on a cotton plant under a wire cage. The efficacy of poisons was determined in a small way by the same plan. The effect of the destruction of pupal cells, as would be accomplished by plowing, was determined both for low and high temperatures. The length of life cycle and the number of stages has been determined for a large series of individuals covering the entire season. The effect of food on the life and egg laying of the moth, the number of eggs deposited by a single female, conditions which affect their vitality, and many other points have been investigated.

Especial attention has been given to the study of the parasites and predaceous enemies of the bollworm, especially as to their value in keeping this pest in subjection. It has always been a pleasing proposition to import from foreign countries the enemies of a pest and array these against it in the hope of lessening its destructiveness. Early in

the present investigation many foreign entomologists were corresponded with in countries where this species was known to occur, in the hope that important enemies of the bollworm might be discovered and imported to this country. No important enemies, however, have been discovered.

SOME RESULTS OF FIELD WORK.

Attention has elsewhere been called to the principal lines of field work. Of first importance is the so-called cultural method, which consists of the employment of all such means as will contribute to the production of an early crop of cotton. This involves especially, (1) the use of seed of early-fruiting varieties; (2) early planting in the spring; (3) early and thorough cultivation; (4) the use of fertilizers to hasten and increase the growth of the plant and the development of fruit.

As has been stated, the cotton crops of Texas and adjacent States have, until recently, been largely produced from native-grown seed, often secured from public ginneries and of unknown variety and origin. The accumulated effect of the climate has been to make the crop later and later in maturing, especially in the absence of selection of seed for earliness and other qualities. During years of severe bollworm injury, the insects, upon their migration from ripening corn to cotton in early August, have found but few fields in which the bolls were sufficiently matured and hardened to be unsuitable for food, and practically all of the fruit has been subject to attack. The importance of early planting to avoid bollworm injury has long been recognized by planters, but sufficient attention has not been given to the matter of using improved varieties of seed and to the adoption of improved farm practices. Many observers have noted that relatively less injury was done by the bollworm and other cotton pests, especially the leaf-worm, to early-planted than to late-planted cotton. Thus Riley, as early as 1885, says:

> Our knowledge of the natural history of Aletia [*Alabama argillacea*] and the yearly occurring experiences with its ravages, teach us that the principal and most effective means of prevention is to hasten the maturity of the plant so that a portion of the crop shall be beyond the reach of harm from the more destructive July and August broods of the worm. * * *
>
> Improving the cotton seed in the direction just mentioned can be accomplished principally by careful selection of early varieties of cotton or possibly by introducing seeds from more northern regions. Early planting is to be strongly urged in this connection, although of course it has its drawbacks in the risks of exceptionally late frosts.

Professor Mally, in discussing certain statistics of the comparative injury by the bollworm to early and late cotton in Texas in 1892, says:

> The late cotton, therefore, shows a loss of 50.6 per cent, while the early cotton shows no real loss. This may be taken as an extreme case, but the general principle remains that late cotton receives by far the greater portion of bollworm attack, virtually protecting the cotton fields about it.

The decided preference of bollworms for squares and young bolls, as compared with maturer and more hardened bolls, is shown in the following tables, as is also the comparative injury to early and late-planted cotton:

TABLE I.—*Showing bollworm injury to early-planted and late-planted cotton.*

BOLLWORM INJURY TO EARLY-PLANTED COTTON.

Date of observation.	Locality.	Number of plants examined.	Total injured.							Total uninjured.							Total fruit on plant.	Average percent of injury.	Date of planting.	Variety of seed and kind of soil.
			Squares.	Very small bolls.	One-fourth-grown bolls.	One-half-grown bolls.	Three-fourths-grown bolls.	Full-grown bolls	Total.	Squares	Very small bolls.	One-fourth-grown bolls.	One-half-grown bolls.	Three-fourths-grown bolls.	Full-grown bolls.	Total.				
Aug. 9	Ladonia	10	31	50	27	17	2	5	138	65	131	106	53	32	59	446	584	23.6	Apr. 1	King. Black-waxy, wooded.
Aug. 11	Ben Franklin	10	13	16	2	4	0	0	35	303	79	88	51	40	23	584	619	5.6	Mar. 29	Hall. Black-waxy, wooded.
Aug. 12	Quinlan	10	0	5	3	1	2	4	15	9	65	2	3	13	165	257	272	5.5	Apr. 1	King. Post-oak.
Aug. 15	Wills Point	20	15	39	9	0	0	0	63	165	340	141	86	82	397	1,211	1,274	4.9	....do....	King. Gray, prairie.
Aug. 22	Paris	5	3	22	9	10	1	0	45	11	43	13	16	21	79	183	228	19.7	Mar. 30	Big Boll. Black, prairie.
Aug. 31	Almont	10	4	27	8	3	3	0	45	57	123	26	64	153	330	753	798	5.6	Mar. 23	King. Red River bottom.
	Total	65	66	165	58	35	8	9	341	610	781	376	273	341	1,053	3,434	3,775	.....		
	Average per cent of injury	.....	9.7	19.5	13.3	11.3	2.3	.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		

INJURY TO LATE-PLANTED COTTON.

Aug. 9	Ladonia	10	75	76	43	20	2	0	216	221	41	73	52	7	1	395	611	35.3	May 2	King. Black-waxy, wooded.
Aug. 11	Ben Franklin	10	56	55	14	5	1	1	132	221	71	69	32	29	17	430	562	23.5	Apr. 15	Hall. Black-waxy, wooded.
Aug. 12	Quinlan	10	4	29	8	10	4	0	55	88	186	45	74	53	46	492	547	10.0	Apr. 25	Big Boll. Post-oak.
Aug. 15	Wills Point	20	18	54	21	8	6	1	108	291	259	82	70	81	186	969	1,077	10.0	May 2	Rowden. Gray, prairie.
Aug. 22	Paris	5	56	67	13	11	7	3	157	210	53	20	34	50	10	377	534	29.6	May 1	Peterkin. Black, prairie.
Aug. 31	Almont	10	149	81	28	8	1	0	267	602	137	62	38	36	81	906	1,173	23.6	June 2	Fleming. Red River bottom.
	Total	65	358	302	127	62	21	5	935	1,633	747	342	300	256	291	3,569	4,504	.....		
	Average per cent of injury	.....	17.9	32.6	29.7	15.9	6.7	1.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		

TABLE II.—*Comparative injury by bollworm to early-planted and late-planted cotton.*

Locality.	Early-planted.			Late-planted.			Per cent in favor of early planting.	Kind of soil.
	Date of planting.	Seed used.	Per cent of injury.	Date of planting.	Seed used.	Per cent of injury.		
Ladonia, Tex.....	Apr. 1	King .	23.6	May 2	King	35.3	11.7	Black-waxy, wooded.
Ben Franklin, Tex.	Mar. 19	Hall ..	5.6	Apr. 15	Hall.....	23.5	17.9	Do.
Quinlan, Tex.....	Apr. 1	King .	5.5	Apr. 25	Gin.....	10.0	4.5	Post-oak.
Wills Point, Tex...	Mar. 30	...do ..	4.9	May 2	Rowden ..	10.0	4.1	Gray, prairie.
Paris, Tex.....	....do ...	Gin...	19.7	May 1	Gin.....	29.6	9.9	Black, prairie.
Almont, Tex	Mar. 23	King .	5.6	June 2	Fleming..	23.6	18.0	Red River bottom.
Average of all observations.	.....	.....	9.3	.....	.....	20.7	11.4	

It will be noted that in determining the percentages of injury observations were made on early and late cotton in the same locality and on the same date as shown in Table I, so that the comparisons are quite fair. The average total injury to early cotton was 9.3 per cent as compared with an average total injury of 20.7 per cent to late cotton. This difference is undoubtedly less than would be the case during seasons of more severe injury than occurred in 1904. The decided preference of the bollworm for squares and young bolls is shown in the figures of average percentages of injury given in both tables. Thus the sum of the percentages of injury, as shown in the tables, to squares and bolls one-half grown or less is 149.7, while on bolls from three-fourths to full-grown the percentages of injury only aggregate 11.5.

Many detailed observations have been made during the course of the present investigation bearing out the above statements, and data as to the comparative freedom of early cotton from bollworm injury have been gathered. This fact has been the basis of one of the principal lines of experimental work.

For the completeness of experiments, the presence in injurious numbers of the bollworm has been necessary. Unfortunately, from an experimental point of view, the injuries of this species during 1904 on the several experiment farms were not sufficiently marked to have made the tests as thorough as could be desired. However, the considerable amount of data collected throughout the season on the effects of the several methods of treatment, and the final results, as shown by the weights of cotton produced, are none the less valuable as indicating the relation of such work to the production of an early crop.

WILLS POINT FARM.

The experimental farm at Wills Point, Tex., on the plantation of Mr. O. L. Johnson, was located on a typical gray prairie soil of that sec-

tion. The land had been in cotton for the three preceding years, and its productiveness was considered to be one-third of a bale per acre. The accompanying plan illustrates the arrangement and treatment of the eight 5-acre plats of this experimental farm, together with the yield.

Experimental cotton plats of Department of Agriculture at Wills Point, Tex., 1904.

Plat I. Five acres. Planted March 30, King seed. Fertilized, C. B. G.[a], 400 pounds per acre. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 986.6.	Plat V. Five acres. Planted April 1, King seed. Unfertilized. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 765.
Plat II. Five acres. Planted March 30, King seed. Fertilized, R. A. P.[b], 300 pounds per acre. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 995.6.	Plat VI. Five acres. Planted April 1, King seed. Fertilized, R. A. P.[b], 300 pounds per acre, plus dressing of nitrate of soda, 100 pounds per acre, when plants had 4 to 6 leaves. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 852.4.
Plat III. Five acres. Planted March 30, King seed. Unfertilized. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 736.4.	Plat VII. Five acres. Planted April 1, King seed. Fertilized, A. P. & P. M.[c], 300 pounds per acre. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 831.4.
Plat IV. Five acres. Planted March 30, King seed. Fertilized, A. P. & P. M.[c], 400 pounds per acre. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 974.	Plat VIII. Five acres. Planted May 2, Rowden seed. Unfertilized. Cultivated 4 times. Hoed 2 times. Yield, pounds seed cotton per acre, 675.4.

[a] C. B. G.—A commercial cotton boll guano; analysis—available phosphoric acid, 8 per cent; potash, 2 per cent; nitrogen, 2 per cent.
[b] R. A. P.—A commercial acid phosphate; analysis—available phosphoric acid, 14 per cent.
[c] A. P. & P. M.—An acid phosphate and potash mixture; analysis—available phosphoric acid, 13.79 per cent; potash, 4.65 per cent.

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More detailed figures are given in the following table:

TABLE III.—*Showing treatment of and results from plats on bollworm experiment farm of Department of Agriculture at Wills Point, Tex., 1904.*

Plat number.	Variety of cotton.	Fertilizer and quantity used per acre.	Date of planting.	Number of times cultivated.	Number of times hoed.	Yield per acre in pounds of seed cotton.	Increase per acre in pounds of seed cotton as compared with Plat VIII.	Value of increase per acre at 3.6868 cents per pound seed cotton as compared with Plat VIII.	Cost of fertilizer per acre.	Net gain per acre.
I	N. C. King..	C. B. G., 400 pounds.	Mar. 30	8	4	986.6	311.2	$11.47	$4.60	$6.87
II	.....do.....	R. A. P., 300 pounds.	....do...	8	4	995.6	320.2	11.81	2.85	8.96
III	.....do.....	Unfertilized.....	....do...	8	4	736.4	61.0	2.24	.....	2.24
IV	.....do.....	A. P. and P. M., 400 pounds.	....do...	8	4	974.0	298.6	11.01	4.30	6.71
V	.....do.....	Unfertilized.....	Apr. 1	8	4	765.0	89.6	3.30	.....	3.30
VI	.....do.....	R. A. P., 300 pounds; sodium nitrate, 100 pounds.	....do...	8	4	852.4	177.0	6.53	5.85	.68
VII	.....do.....	A. P. and P. M., 300 pounds.	....do...	8	4	831.4	156.0	5.75	3.22	2.53
VIII	Rowden....	Unfertilized.....	May 2	4	2	675.4	.....	.....	.....	.....

Aside from the yields of cotton, the influence of the several treatments on the fruiting of the plant was determined by actual counts of all the fruit on 20 plants for each plat, on several different dates during the season.

Vigorous, well-branched plants were selected in various parts of each plat. These plants were not marked, and consequently a different set of plants was used each time the counts were made. The fruitage was determined in this way five times during the summer, at intervals of about sixteen days. The first count was made on June 9, square production having just begun; the last on August 15, when the bolls were beginning to open.

The prime object in making these records was to determine the relative earliness of fruit production, (1) with King seed, early planting, fertilizers, and thorough cultivation; (2) with King seed, early planting, no fertilizer, and thorough cultivation, and (3) with Rowden (native) seed, late planting, no fertilizer, and ordinary cultivation. The records made on plants grown under the conditions named in the last group are used as a basis of comparison.

TABLE IV.—*Showing rate of fruiting on respective plats of bollworm experiment farm of Department of Agriculture at Wills Point, Tex., 1904.*

Plat number.	Date of examination.	Average number of squares per plant.	Average number of bolls per plant.				Average increase per plant in number of—				
			One-fourth grown.	One-half to three-fourths grown.	Full-grown.	Open.	Squares as compared with plat 8.	One-fourth-grown bolls as compared with plat 8.	One-half to three-fourths grown bolls as compared with plat 8.	Full-grown bolls as compared with plat 8.	Open bolls as compared with plat 8.
I	June 9	6 5/8	.....	.....	.....	.....	5 1/2	.....	.....	.....	.....
II	....do...	5 1/4	.....	.....	.....	.....	6 3/8	.....	.....	.....	.....
III	....do...	2 3/8	.....	.....	.....	.....	1 1/2	.....	.....	.....	.....
IV	....do...	6 3/8	.....	.....	.....	.....	5 1/2	.....	.....	.....	.....
V	....do...	3 1/2	.....	.....	.....	.....	2 3/8	.....	.....	.....	.....
VI	....do...	5 3/8	.....	.....	.....	.....	4 1/2	.....	.....	.....	.....
VII	....do...	6 3/8	.....	.....	.....	.....	0 3/8	.....	.....	.....	.....
VIII	....do...	1 1/8	.....	.....	.....	.....	.....	.....	.....	.....	.....
I	June 23	37 1/2	3/8	1/8	.....	.....	38 1/2	3/8	1/8	.....	.....
II	....do...	34 3/4	3/8	1/8	.....	.....	27 7/8	3/8	1/8	.....	.....
III	....do...	20 3/4	1/8	.....	.....	.....	12 1/2	1/8	.....	.....	.....
IV	....do...	52 3/4	3/8	.....	.....	.....	25 3/8	3/8	.....	.....	.....
V	....do...	30 1/2	1/8	.....	.....	.....	13 1/4	1/8	.....	.....	.....
VI	....do...	31 3/8	3/8	.....	.....	.....	24 3/8	3/8	.....	.....	.....
VII	....do...	32 3/4	3/8	1/8	.....	.....	26 3/8	3/8	1/8	.....	.....
VIII	....do...	7 1/8	.....	.....	.....	.....	.....	.....	.....	.....	.....
I	July 9	100 3/8	5 3/4	2 1/4	1/8	.....	65 3/8	3 1/4	2 1/8	1/8	.....
II	....do...	73 1/8	3 1/8	1 3/8	.....	.....	38 1/8	2 3/8	1 3/8	.....	.....
III	....do...	51 3/4	2 1/8	1/8	.....	.....	16	1 3/8	1/8	.....	.....
IV	....do...	89 1/2	5 1/8	1 1/2	.....	.....	54 1/8	4 3/8	1 1/2	.....	.....
V	....do...	44 1/2	2 1/8	3/8	.....	.....	9 1/2	1 1/2	3/8	.....	.....
VI	....do...	74	4 1/2	1/8	.....	.....	38 1/2	3 3/8	1/8	.....	.....
VII	....do...	81 1/2	3 3/8	1 1/8	1/8	.....	40 3/8	2 3/8	1 1/8	1/8	.....
VIII	....do...	35 3/8	1 3/8	.....	.....	.....	.....	.....	.....	.....	.....
I	July 25	64 3/8	21 1/8	18 3/8	9 1/2	.....	2 3/8	12 1/2	15 3/8	9 3/8	.....
II	....do...	67	18 3/8	12 3/8	9 3/8	.....	4 1/8	2 3/8	9	8 1/8	.....
III	....do...	76 1/2	10 3/4	6 1/8	5 3/8	.....	14 3/8	2 3/8	3 1/8	4 1/8	.....
IV	....do...	99 1/4	17 1/8	9 1/8	8	.....	37 3/8	9 1/8	6 3/8	7 1/8	.....
V	....do...	59 3/8	12 3/8	5 1/8	4 1/4	.....	−2 3/8	4 3/8	2 1/8	4 3/8	.....
VI	....do...	82 3/8	19 1/8	9 1/8	7 3/8	.....	20 3/8	11 1/8	6 1/8	6 1/8	.....
VII	....do...	70 1/4	23 3/8	11 1/2	8	.....	9 1/2	15 3/8	8 1/8	7 1/8	.....
VIII	....do...	62 3/8	8 3/8	3 3/8	3/8	.....	.....	.....	.....	.....	.....
I	Aug. 15	4 3/8	3 1/4	8 3/8	12 3/8	6 1/2	−10 1/2	− 7	1 1/8	4 7/8	5 3/8
II	....do...	10 1/2	10 1/2	8 3/8	16 3/8	3 7/8	− 3 3/8	− 3	2 1/8	8 1/2	3 3/8
III	....do...	14 1/2	13 1/2	8 3/8	14 1/2	1 1/8	− 3/8	4 1/2	3 1/8	6 1/2	1 1/8
IV	....do...	5 1/2	12 1/2	8 3/8	16 3/8	4 1/2	− 8 1/2	− 2 3/8	1 1/8	8 3/8	3 7/8
V	....do...	8 1/2	9 1/2	8 3/8	18 3/8	1 1/8	− 5 1/2	− 1 3/8	1 1/8	10	1 1/8
VI	....do...	12 3/8	10 1/2	9 1/2	15 1/2	3 1/2	− 2 3/8	− 3/8	1 3/8	7 1/2	2 1/2
VII	....do...	2 1/8	9 1/2	8 1/2	13 3/8	3 1/2	−11 1/2	− 1 3/8	1 1/8	5 3/8	3 1/8
VIII	....do...	14 1/4	10 1/2	7 1/2	8 3/8	1 3/8	.....	.....	.....	.....	.....

The counts made on the several dates plainly show that the plats in the first group, that is, Nos. I, II, IV, VI, and VII, had a decided advantage over the others in earliness of fruit production; those in the second group, that is, Nos. III and V, were about intermediate, while No. VIII fell far behind all the others. Plats of the first group reached their maximum square production about July 9; those in the second group about two weeks later; and plat VIII about a week later than the second.

The decided uniformity of the results of the counts on the several dates is noteworthy; also their conformity with the earliness as shown

by the first picking. The total weight of the cotton picked from the several plats bears out the results of the counts, for it is noticeable that the maximum square production on the unfertilized plats never reached as high as on those which were fertilized, and Plat VIII, which had ordinary treatment, was considerally below Plats III and V, unfertilized, but which were planted with King seed and thoroughly cultivated. The same effects are noticeable in the maximum boll production.

Bolls which are full grown by August 15, as shown by counts of injured and uninjured fruit, are practically safe from bollworm injury; hence the advantage of early-fruiting varieties, early planting, fertilizers, and thorough cultivation may be readily seen: for on the above date Plats I, II, IV, VI, and VII show an average of 19⅛ bolls per plant, which would be practically out of danger of bollworm injury. Of these 19⅛ bolls there was an average of $4\frac{9}{20}$ bolls per plant open on that date. Plats III and V show an average of $18\frac{3}{20}$ bolls per plant practically out of danger, an average of $1\frac{7}{20}$ of these being open. Plat VIII had $9\frac{3}{10}$ bolls per plant out of danger, or less than half the number which on the fertilized plats would be quite sure of escaping bollworm injury.

PITTSBURG FARM.

The experimental farm at Pittsburg, Tex., on the plantation of Mr. J. F. Harrison, was located on a typical sandy soil of that section. It was supposed that fertilizers would exert considerable influence on the production of cotton on a soil of this character, and this feature of the work was emphasized. The land used was said to have been in cultivation continuously for the past sixty years. In 1902 it was planted to corn and in 1903 to cotton. The productiveness of the land was considered to be one-fourth bale per acre.

The accompanying plan shows the treatment of, and the results from, the respective plats involved in this fertilizer experiment:

Experimental cotton plats of the Department of Agriculture at Pittsburg, Tex., 1904.

Plat I. Five acres. Hetty seed. Planted April 13. Fertilized, R. P. C.[a] 300 pounds per acre. Cultivated 8 times. Hoed 3 times. Yield, pounds seed cotton per acre, 1,403.8.	Plat III. Five acres. Hetty seed. Planted April 13. Fertilized, R. A. P.[c] 320 pounds per acre. Cultivated 8 times. Hoed 3 times. Yield, pounds seed cotton per acre, 1,202.8.
Plat II. Five acres. Hetty seed. Planted April 13. Fertilized, C. B. G.[b] 400 pounds per acre. Cultivated 8 times. Hoed 3 times. Yield, pounds seed cotton per acre, 997.8.	Plat IV. Five acres. Hetty seed. Planted April 13. Unfertilized. Culivated 8 times. Hoed 3 times. Yield, pounds seed cotton per acre, 694.

[a] R. P. C.—A commercial potash compound, analyzing—available phosphoric acid, 10 per cent; potash, 2 per cent.

[b] C. B. G.—A commercial cotton boll guano, analyzing—available phosphoric acid, 8 per cent; potash, 2 per cent; nitrogen, 2 per cent.

[c] R. A. P.—A commercial acid phosphate, analyzing—available phosphoric acid, 14 per cent.

The comparative earliness of the crop, the increase and value of the same, and the net gain by the use of fertilizers are shown more in detail for the respective plats in the table below:

TABLE V.—*Showing treatment of, and results from, plats in Department of Agriculture's bollworm experimental farm at Pittsburg, Tex., 1904.*

Plat number.	Variety of cotton.	Fertilizer and quantity used per acre.	Date of planting.	Times cultivated.	Times hoed.	Yield per acre in pounds of seed cotton.	Weights of seed cotton picked— August 29–30.	September 7–19.	September 23–October 3.	October 10–28.	November 23–26.	Increase per acre in pounds of seed cotton as compared with Plat IV.	Value of increase per acre at 3.314 cents per pound seed cotton.	Cost of fertilizer per acre.	Net gain.
I	Hetty.	300 pounds, R. P. C.	Apr. 13	8	3	1,403.8	148.6	358.8	397.4	375.6	123.4	709.8	$23.53	$3.23	$20.30
II	...do..	400 pounds, C. B. G.	...do...	8	3	997.8	158.6	340.6	266.4	162.2	70.0	303.8	10.07	4.60	5.47
III	...do..	320 pounds, R. A. P.	...do...	8	3	1,202.8	232.0	499.0	307.2	125.8	38.8	508.8	16.86	3.04	13.82
IV	...do..	Unfertilized.	...do...	8	3	694.0	.....	377.0	.....	297.6	19.4	.....	.....	.....	.....
Average price per pound lint cotton.....							11 1/16	10 7/16	10 1/16	9 1/16	9 1/16	.....	.....	.....	.....

Plats I and IV are compared graphically with respect to earliness and yield in figure 2.

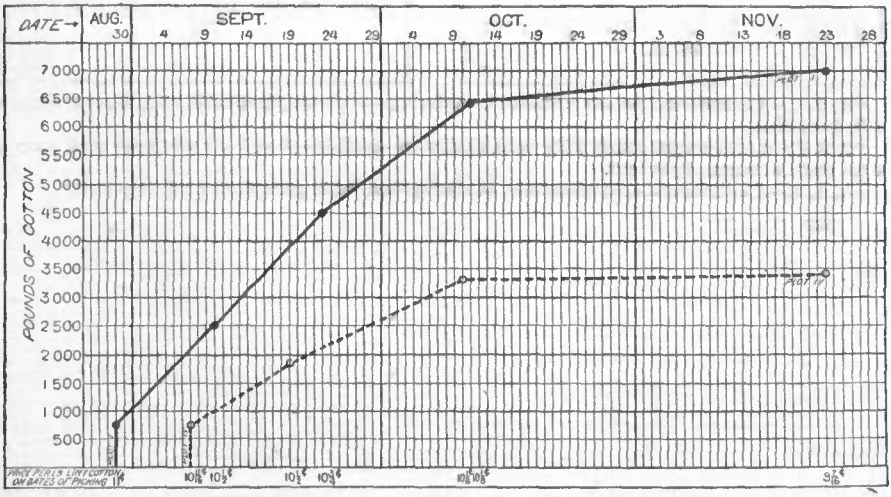

FIG. 2.—Diagram comparing Plats I and IV of the Pittsburg (Tex.) farm, fertilized and unfertilized, respectively, with regard to earliness and yield of seed cotton.

In connection with the above results as to final yield should be considered certain data relative to the rate of fruit production during

the season as determined by counts on different dates on 20 plants on each plat. The important results of these counts are indicated in the following table:

TABLE VI.—*Showing rate of fruiting on respective plats of Department of Agriculture's bollworm experimental farm at Pittsburg, Tex., 1904.*

Plat number.	Dates of examination.	Average number of squares per plant.	Average number of bolls per plant.				Average increase per plant in number of—				
			One-fourth-grown.	One-half to three-fourths-grown.	Full-grown.	Open.	Squares as compared with Plat IV.	One-fourth-grown bolls as compared with Plat IV.	One-half to three-fourths-grown bolls as compared with Plat IV.	Full-grown bolls as compared with Plat IV.	Open bolls as compared with Plat IV.
I	June 24	21 6/20	.....	.....	.....	.....	9 16/20	.....	.....	.....	.....
II	....do...	19 6/20	.....	.....	.....	.....	7 16/20	.....	.....	.....	.....
III	....do...	21 1/20	.....	.....	.....	.....	10 11/20	.....	.....	.....	.....
IV	....do...	11 18/20	.....	.....	.....	.....	.....	.....	.....	.....	.....
I	July 13	62 3/20	21 18/20	11 10/20	1/20	.....	16 13/20	14/20	1	1/20	.....
II	....do...	73 5/20	42/20	11 3/20	3/20	.....	27 14/20	2	1 3/20	3/20	.....
III	....do...	61 14/20	42/20	1 1/20	.....	.....	16 5/20	2	1/20	.....	.....
IV	....do...	45 11/20	2 4/20	1/20	.....	.....	.....	.....	.....	.....	.....
I	July 28	81 11/20	16 3/20	5 18/20	4 13/20	.....	15 2/20	5 7/20	1 13/20	2 7/20	.....
II	....do...	90 12/20	14 17/20	5 18/20	5 8/20	.....	24 7/20	3 16/20	1 18/20	3 2/20	.....
III	....do...	103 17/20	12 5/20	6 6/20	4 2/20	.....	37 6/20	1 12/20	1 18/20	2 2/20	.....
IV	....do...	66 9/20	10 1/20	4 2/20	2 0/20	.....	.....	.....	.....	.....	.....
I	Aug. 18	25 14/20	16 3/20	15 5/20	9 5/20	1/20	−8 3/20	1 2/20	3 17/20	4 17/20	1/20
II	....do...	31 8/20	20 11/20	13 11/20	10 16/20	1/20	−2 8/20	5 16/20	2 6/20	5 18/20	1/20
III	....do...	36 18/20	17 2/20	13 17/20	5 12/20	1/20	3 2/20	2 7/20	2 19/20	1/20	1/20
IV	....do...	33 16/20	14 15/20	11 8/20	4 14/20	3/20	.....	.....	.....	.....	.....

SUMMARY REMARKS CONCERNING THE EXPERIMENTS WITH CULTURAL METHODS.

In the case of field experiments involving questions of the character of those presented above, final conclusions may not be drawn as the result of one or even several years' tests. Variations in seasons and other conditions often produce results one year not verifiable the next; and what appears desirable for one character of soil may not be useful on another. The writers would, therefore, be entirely unwarranted in making specific recommendations, especially as regards the use of certain fertilizer elements, on the data secured in the course of last year's investigation.

Certain general statements are, however, apparently warranted. At the Pittsburg, Wills Point, and other experimental farms the use of fertilizers resulted in a notably earlier and larger crop of cotton, as compared with the unfertilized check plats.

On soils deficient in one or more of the three principal elements of plant food, namely, phosphoric acid, nitrogen, and potash, the application of the needed element or elements results in a more rapid and

larger growth of the plant and a consequent earlier and greater production of squares. It would appear that herein lies the principal value of fertilizers, as related to the production of an early crop.

On the Pittsburg farm, attention is called to the larger and earlier yields obtained from the use of a fertilizer containing 10 per cent of phosphoric acid and 2 per cent of potash, and from the use of 14 per cent acid phosphate alone, as compared with a complete fertilizer analyzing, phosphoric acid 8 per cent, nitrogen 2 per cent, and potash 2 per cent. On the Wills Point farm the largest yield was obtained from the use of 14 per cent acid phosphate. Plats I, II, and IV, however, show approximately the same total yield. The comparative earliness may be indicated from the following weights of seed cotton picked by August 26: Plat I, 2,325 pounds; Plat II, 2,029 pounds; Plat IV, 2,554 pounds. This gives again a slight balance in favor of an acid phosphate and potash fertilizer as to earliness of crop. It may also be mentioned here that in the fertilizer experiments in 1904, on the plantation of Capt. B. D. Wilson, Hetty, Tex., on rich "bottom" soil, the use of 400 pounds per acre of a phosphoric acid and potash mixture gave a considerably larger early and total yield of cotton than did the use of 300 and 450 pounds per acre, respectively, of phosphoric acid. The first picking from phosphoric acid and potash mixture plats, September 3, was 499 pounds seed cotton per acre. From the plat treated with 300 pounds acid phosphate, 354⅔ pounds of seed cotton per acre were secured; and from the plat receiving 450 pounds of acid phosphate the yield was 355⅔ pounds of seed cotton per acre. The total yield of seed cotton per acre from the respective plats was 1,387⅔ pounds, 1,153 pounds, and 1,280⅔ pounds.

It is, however, only intended to point out the usefulness, in general, of employing fertilizers in a system of cotton culture designed to produce a crop ahead of bollworm injury. The exact character of the fertilizer and the quantity per acre to be used are matters of further experimentation. The previously tabulated data in regard to fertilizers should furnish planters with a basis for experimentation by which they will finally arrive at conclusions true for their respective soils.

Of equal importance in the production of early cotton is the use of varieties with an inherent tendency to begin fruiting early in the growth of the plant, or low on the plant, and on which the joints are short. Observant planters need not be told of the great difference in fruiting habit of different varieties of cotton. The long-limbed sorts are necessarily later in setting squares, and they are also less prolific than those with shorter joints. The desirable qualities, as early fruiting, good staple, etc., may be perpetuated and improved by seed selection. Seasonal conditions, such as a shorter growing season, have led, in the northern part of the cotton belt, to the use of early-fruiting, prolific varieties in those sections. Seed of such varieties, especially the King,

has recently been extensively planted in Texas on account of these characteristics, in both the bollworm and boll weevil infested regions. The importance of the use of selected early-fruiting varieties, as compared with the native "run-down" gin seed, was well illustrated in the investigations during 1903. On the plantation of Capt. B. D. Wilson, at Hetty, Tex., under conditions of severe bollworm injury, early planted King seed produced an average of 1,348 pounds per acre of seed cotton, as against 187 pounds per acre of early-planted but late-maturing gin seed. The advantage of early planting is emphasized by results secured on various farms. On the Wilson farm in 1903 early-planted King with thorough cultivation gave 1,348 pounds seed cotton per acre, as compared with 360 pounds per acre from late-planted King also with thorough cultivation.

Early and thorough cultivation is another important factor in the production of early cotton. Plants should be chopped out as early as practicable to admit of free branching and consequent square production. The fertility of the soil, either native or introduced by means of fertilizers, may be used by plants only in solution. Consequently, for the conservation of moisture and other reasons, timely and frequent cultivations are of the utmost importance.

TRAP CROPS.

Attention has been elsewhere called to the decided preference of bollworms for corn as compared with other plants upon which it is known to feed. This preference permits of the use of corn in a way calculated to protect cotton from injury.

The corn should be planted in belts through the cotton field at a time that will result in its being in tassel and silk about the first of August. By this time moths are developing from larvæ matured in the roasting ears of neighboring corn which has now begun to ripen and is no longer attractive to the moths for egg-laying purposes. In the natural course of events, the moths migrate to cotton fields, where they deposit the bulk of their eggs. Finding these belts of corn in tassel and silk, however, they deposit on them the greater part of their eggs, and correspondingly neglect the cotton plants. The September generation of larvæ is sometimes a source of considerable injury, especially to very late cotton. Corn may easily be brought into silk so as to attract moths of this generation by planting only a portion of the belts through the cotton fields at the time of first planting and then completing the work two or three weeks later. The same results may be secured by planting patches of corn here and there over the plantation, following crops of oats, wheat, or Irish potatoes. Cowpeas are very attractive to bollworm moths, owing to their fondness for the nectar profusely secreted by this plant. Thus the corn

trap rows may be made more effective by planting rows of peas alternately with rows of corn. The peas should come into full bloom at the time the corn is silking. This will necessitate planting the peas about the time the corn appears above the ground. The advantage gained by the use of trap crops can not be expressed in pounds of seed cotton, as it is impossible to arrange a test so that the area left for comparison will be subjected to the same conditions without having it adjacent and consequently equally subject to protection by the corn. Bollworm moths fly freely, and are therefore attracted to fresh corn from a considerable distance, and the influence of the trap rows is thus quite general.

During 1903 tests of corn trap crops for protecting cotton against the more destructive August generation of bollworms were made at Calvert and Wills Point, Tex. Early in August the number of eggs upon 8 typical plants in the trap rows at Wills Point was found to be, on an average, 495 per plant, 804 eggs being the maximum number found on a single plant. No account was taken of eggs deposited on plants previous to or succeeding this time. From these figures some idea may be gained of the vast number of eggs which are thus diverted from cotton. In 1904 tests of corn as a trap crop were made at Sulphur Springs, Quinlan, and Hetty, Tex., and at Shreveport, La. The same general plan was carried out in all of the above localities, protection from the August brood only being sought. Belts from 10 to 40 feet wide extending across the field were left unplanted at the time of planting cotton, and these were seeded to Mexican June corn by June 1 in rows from 5 to 6 feet apart. Ten days later cowpeas were planted between the rows of corn, thus leaving ample room for cultivation. The corn was planted in about the proportion of 10 rows to 40 rows of cotton, and the individual fields varied from 20 to 40 acres.

The following table, computed from counts made of the number of eggs on 20 typical plants in trap rows on the farm of Mr. J. T. Hargrove, Sulphur Springs, Tex., will give an idea of the number of eggs kept from the cotton by a few acres of trap corn. The figures show the average number of eggs for each plant and the average number on the various portions of the plants:

TABLE VII.—*Distribution and average number of bollworm eggs on corn.*

Date of examination.	Number of eggs on—					Condition of corn.
	Entire plant.	Leaves.	Sheaths.	Tassels.	Silks.	
July 28	338.4	88.85	55.55	64.93	129.1	Many plants not in silk.
August 16	52.55	12	7.85	10.8	21.9	Corn in roasting ear; silks drying.

During a year of greater bollworm abundance the number of eggs that would be deposited on corn would doubtless far exceed the numbers here given. The number of eggs occurring on an acre of trap corn at one time, as based on the above figures, is surprisingly great. Taking the average number of eggs per plant on July 28, as given in the table, the protection afforded by the plants on a single acre may be calculated in a theoretical way. Assuming the corn rows to be 6 feet apart and the plants 1½ feet apart in the row, there would be on an acre 4,840 plants. On the average of 338.4 eggs per plant, as found above, there would be 1,637,856 eggs distributed over the acre of corn. By a series of observations it has been determined that a single bollworm feeding freely on cotton will destroy on an average 8 squares, 1 flower, and 1⅔ bolls during the course of its growth. Assuming that all of the fruit destroyed would have eventually matured, there would be a total destruction of 17,470,464 bolls. On an average of 70 bolls to the pound of seed cotton, this would mean a destruction of 249,578 pounds of cotton in the seed, or at the rate of 1,500 pounds seed cotton to the bale, 166 bales.

It must be remembered, however, that in the above calculations it was assumed that from every egg a mature larva would develop. This would be far from the case in reality. In fact it has been observed that on an average but one larva reaches maturity from about 50 eggs deposited on corn. It was further assumed that all of the squares and flowers injured would have otherwise reached maturity, which in fact would not be the case, as many squares and young bolls are shed by the plants on account of unfavorable weather or other conditions. However, after making due allowance for all of these conditions, the benefits to be derived from a proper use of corn as a trap crop are seen to be very great.

It might appear at first sight that the practice of furnishing the bollworm with an abundance of its preferred food would simply result in its greater increase and consequent destructiveness. This, however, does not result, for when the eggs are concentrated on the corn plants, as on the silks, they are very largely destroyed by a certain parasite and by predaceous enemies, and the larvæ hatching from these eggs are largely killed by the cannibalistic habits of the bollworms themselves. Out of some 15 to 30 young larvæ which may usually be found in a recently silked ear of corn, but one or two bollworms will eventually reach maturity.

Numerous instances have come under the observation of the writers where planters, in attempting to make use of trap crops, have made the mistake of planting the corn at the usual time in the spring. The result has been, that the cotton has suffered greater injury than would otherwise have occurred. The success of the trap crop idea as here

considered depends entirely on having the corn in tassel and silk on or about the first of August, and it must be planted considerably later than the normal time of planting corn in the spring. June corn planted the last of May or first of June, with good cultivation, will be silking and tasseling freely by August 1.

The greatest benefit will come from the use of corn as a trap crop in its general adoption by the planters of a neighborhood. In the case of large plantations it is quite possible to adopt a system of growing late corn, after oats, wheat, or other early-maturing crops, which will attract the bollworms from the plantation generally. An instance of this practice may be cited on the plantation of Mr. F. L. Maxwell, of Mound, La. It has been the practice of this gentleman to grow small areas of late corn after oats here and there over the plantation to the almost complete protection of his large cotton crop.

USE OF ARSENICAL POISONS.

The opinion prevails more or less generally among cotton planters that the bollworm may not be successfully poisoned, by reason of the fact that it bores to the interior of squares and bolls, and does not feed on the exterior parts of the plant to any extent. Such a belief is true only of the later stages of the larva. The average planter seldom has his attention attracted by so small a creature as a newly hatched bollworm, and it thus results that the habits of the insect during its early larval existence are practically unknown to him. This unobserved period in the development of the larva is the only time when poisons may be expected to exert any considerable influence in bollworm control.

From extended studies of the egg-laying habits of the moth and the actions of the newly-hatched larvæ there is every reason to believe, on theoretical grounds, that, by the application of poison to cotton at about the time the eggs of the large August generation begin to hatch, the injury from this insect may be greatly reduced. A series of observations made during the summer of 1903 on the distribution of eggs on cotton plants, as determined by watching the moths while ovipositing, showed that 73 per cent of the eggs were so placed that the resulting larvæ would be readily susceptible to poison. By carefully examining several plants, 65 per cent of the eggs were found to be on other parts than the squares, flowers, and bolls. During 1904 similar records were made by watching the moths ovipositing in cotton fields. The combined record of 25 moths is given below:

Distribution of bollworm eggs upon cotton plants.

	Eggs.
Leaves, upper surface	191
Leaves, lower surface	194
Squares	326
Flowers	110
Bolls	120
Growing tips	46
Stems	64
Petioles	29
Weeds	20
Objects on ground	21
Dead leaves	20

The total number of plants oviposited on by these 25 moths was 1,175. All larvæ hatching from eggs deposited elsewhere than on the squares and flowers may, for reasons to be given, be considered as capable of destruction by poison. Therefore, of the 1,141 eggs deposited, 705, or about 62 per cent, would fall in this class.

On account of the important bearing on the subject of poisoning, as before mentioned, the habits of the newly hatched larvæ have been quite carefully studied. Immediately upon its escape from the egg the little larva devours its deserted egg-shell and soon afterwards begins a restless search for food. If it hatches from an egg placed upon a square or flower, it may soon effect an entrance, but if situated elsewhere, as on a leaf, it may wander about here and there, frequently tasting or rasping the epidermis of the leaf or other portion of the plant where it may be, in its efforts to find suitable food.

This apparently aimless search is often continued for several hours. The same path is often crossed and recrossed many times with short intervals of surface feeding along the way. Many of these minute larvæ perish in their attempts to find suitable food; others succeed in reaching some tender-growing portion of the plant, as the terminal bud of unfolded leaves, which is soon penetrated. Although considerable traveling may be done later in the search for fresh food, but little food is taken on the surface. Larvæ which hatch from eggs placed upon bolls may rasp the epidermis but are unable to enter except in case of the smallest bolls. Therefore these, as well as larvæ from eggs placed upon the leaves, petioles, stems, etc., are compelled to seek more tender portions. This period of what might be called external feeding varies greatly in different individuals, lasting, as a rule, probably from a few hours to a day, or even more.

Considering the above facts, the necessity of applying poisons at the proper time is apparent. No arbitrary date may be given, owing to the variability of the time at which the larvæ begin to hatch in destructive numbers in different localities. However, the planter may determine this time approximately by careful observation. When

moths are seen to be present in any considerable numbers in cotton fields, the poison should be applied immediately. The moths do not become abundant in the fields, as a rule, until the August generation appears, which is during the last few days of July or the first week of August. As has been stated, poisons should be applied when the eggs begin to hatch in numbers, about the first of August, and not when the larvæ have attained considerable size, as they have three weeks later. The first application should be made, as a rule, about the last of July, and should be repeated in about a week or ten days. In case of rain following an application, it should be repeated immediately. Sometimes a third treatment at a later date is desirable. When the dusting method is employed, the application should be made early in the morning or after a shower, as the moisture on the plants is important to retain the dust as it comes in contact with the foliage and other parts.

To illustrate the efficiency of poison when applied at the proper time in killing newly hatched larvæ, the following is of interest: The results were obtained by Mr. C. T. Brues in a small experiment conducted at the laboratory at Paris, Tex. On September 17, two plants which were squaring freely were covered with wire screen cages, one plant having previously been lightly dusted with paris green diluted with dry slaked lime. About 200 hundred eggs which were ready to hatch were placed upon each plant. Observations were made each day of the number of fruits injured until October 16, when all of the surviving larvæ had entered the soil to pupate. Only 1 square was injured during this period on the poisoned plant, while on the unpoisoned check plant 31 squares, 2 flowers, 12 small and 2 large bolls were destroyed. Notwithstanding the fact that there were heavy rains during the nights of September 20 and 21, the destruction of the larvæ by one application was practically complete. In these instances the larvæ all hatched practically at the same time and shortly after the poison had been applied. Such uniformity in hatching would not be the case in the field, and therefore such complete extermination could not be expected.

As between the dusting and spraying methods of applying poisons, the former seems more practicable. The main objection to the use of a spray is the difficulty usually found in securing water in proximity to fields, and the greater time required in the application of poisons in liquid condition. Geared machinery may be secured for poisoning by either method, but the rather primitive way so largely used in combating the cotton caterpillar, by dusting the poison through bags tied to each end of a pole and carried by a man on horseback, has a decided advantage on account of cheapness of apparatus. By this means some 20 to 25 acres may be poisoned during the few hours suitable for this work in the early morning and late evening. Where the poison is

dusted over the plants, from 2 to 3 pounds of Paris green should be used per acre, and in spraying the poison should be used at the rate of 1 pound to each 50 gallons of water. Fifty gallons of water will spray approximately 1 acre of cotton.

In purchasing poisons reliable brands should be insisted upon. Where large dusting machines are used, it will be more economical to mix the Paris green with 3 or 4 times as much flour, or even more, or with sifted, dry, or air-slaked lime.

During the summer of 1903 very favorable results were obtained in poison experiments at Hetty and at Calvert, Tex., by reason of the great abundance of bollworms at that time. At Hetty, Paris green was applied by means of bags on a pole. In this case a net gain of $5.79 per acre was realized. At Calvert, Paris green was applied both as a spray and in the dust form. By the former method a net gain of $6.99 was secured, and by the latter a net gain of $4.44. Although several experiments were conducted during the season of 1904, no decided results were obtained owing to the more general absence of bollworms in destructive numbers.

In north Texas especially, there is a decided prejudice on the part of cotton pickers against picking cotton from fields that have been poisoned. Several reported instances of fatal poisoning, through cuts or sores on the hands, are cited in support of these objections. The writers have investigated several of these reports of poisoning, and no evidence has been found to warrant the conclusion that there is any danger to pickers from the proper use of poison in bollworm control. Harmony of action in poisoning on the part of planters would largely do away with the present prejudice of pickers against this work.

INEFFECTIVE METHODS OF BOLLWORM CONTROL.

Attention has at various times been called to the inefficiency of certain methods often used by planters with a view to controlling the bollworm. A common error is in the burning of lights to attract and destroy the moths, and one less frequently employed is the use of poisoned sweets placed in pans here and there in the cotton fields.

During the past two years, under varying conditions of weather, both of these procedures have been thoroughly tested. As a result the previously demonstrated futility of such work has been fully verified. Attention is called to the uselessness of such operations that the planter may avoid this needless expense.

RECOMMENDATIONS.

The work of the Bureau of Entomology during the past two years has shown that by the adoption of certain cultural expedients, desirable

in themselves, a satisfactory crop of cotton may be grown during years of severe bollworm injury. This requires, for best results, the adoption of all methods useful in the production of an early crop, and is based on the fact that cotton is not attacked in force by bollworms until the corn in surrounding fields begins to harden, which in general is about the first of August.

In the cultural system, by which profitable crops of cotton may be grown in spite of the presence of the bollworm, the following procedures are important: (1) Thorough plowing of the land during the fall or winter months to destroy as many as possible of the hibernating pupæ in the soil; (2) the use of seed of early-fruiting varieties of cotton; (3) the use of fertilizers to hasten and increase the growth of plants and the formation of fruit; (4) planting at the first practicable date in the spring; (5) early and frequent cultivation.

The use of corn as a trap crop is recommended. In planting cotton leave vacant strips across the fields every 200 or 300 feet sufficiently wide for planting 10 or 12 rows of corn. The corn should be planted so that it will be in prime silking condition about August 1. Under favorable conditions of rainfall and with good cultivation, Mexican June corn planted by June 1 will be in proper condition by August 1. Plant cowpeas in the corn belts so that the peas will be flowering at the time the silks and tassels appear on the corn, thus furnishing food for the moths and keeping them out of the cotton fields. Much the same benefits may be secured by planting patches of late corn on different parts of the plantation, as after oats, wheat, etc. In all cases peas should be planted in the corn. The corn thus grown may be harvested in the usual way. *The corn should not be planted for trap-crop purposes in belts through the cotton field at the usual time of planting in the spring. To be of value in bollworm control it should not be in silk and tassel until about August 1.*

During seasons of severe bollworm injury, poisons may be profitably used on cotton. Poisons should be applied late in July and early in August to secure the maximum destruction of young larvæ of this generation. Two or three applications may be necessary at intervals of a week or ten days. After rains the application should be immediately repeated. Paris green at the rate of from 2 to 3 pounds per acre for each application will be satisfactory. It is best applied in a dry condition, either pure or mixed with cheap flour, and dusted over the plants by the usual pole-and-bag method or by means of a dust-spray machine.